APPENDIX A

TECHNICAL NOTES

NEW FEATURES IN THE 1998 NATIONAL PATTERNS REPORT

Symmetry of R&D tables with respect to type of performer and sources of funds. As mentioned in the General Notes, a new feature of this report is that the first four appendix tables are symmetrically arranged to allow for direct comparisons of R&D data organized in two ways: (1) by performer first and then by source, or (2) by source first and then by performer. The first case effectively asks, "what type of organization performs the R&D, and for that type of performer, from what kinds of organizations does it receive its funding?" The second case effectively asks, "what type of organization provides funding for R&D, and to which kinds of performers does it provide those funds?"

For example, the upper left-hand corners of appendix tables B-1A and B-2A are displayed below, which represent cases 1 and 2, respectively. In table B-1A, the column for the Federal Government as a performer, as defined in the first row, is not subdivided because the Federal Government is the only source of funds for Federal intramural research. Industry performance, in contrast, is subdivided by the two main sources of industrial performance—the Federal Government and industry's own funds.

In table B-1B, on the other hand, the Federal Government as a source defines a column in the first row, which is subdivided into several columns in the second row for the performers that receive those funds, such as the Federal Government itself and industry.

The third row of each table provides the column number for appendix table B-6, containing annual historical data from 1953–98 (where data for 1997 and 1998 are preliminary). Note, for instance, that, in appendix table B-1A, industrial performance that is funded by Federal support is designated as column "[4]" in appendix table B-6. In appendix table B-1B, Federal support that is directed to industry performers is also designated as column "[4]" because these two concepts are identically equal, and thus, they are represented by the same column in appendix table B-6. In fact, whenever one column of an appendix table contains the same column-number designation as that of another column in another table, both columns are identical in definition. This aspect of the column-number designations was deliberately designed in order to reduce uncertainty among researchers when deciding which columns of data to use.

Table 1. Illustration of the upper left-hand corner of appendix Table B-1A, on "National expenditures for R&D, by performing sector and sources of funding"

Performing Sector:	Total U.S.	Federal Govt.	Industry			Industry FFRDCs
Funding Sector:	Total U.S.	Federal Govt.	Total	Federal Govt. 2/	Industry 3/	Federal Govt. 2/
Data Column	[1]	[2]	[3]	[4]	[5]	[6]
Calendar Year 5/	[Millions of current dollars]					
1991 6/	160,521	15,249	114,675	24,095	90,580	2,277
1992	164,933	15,853	116,757	22,369	94,388	2,353
1993	165,188	16,532	115,435	20,844	94,591	1,965

Table 2. Illustration of the upper left-hand corner of appendix Table B-1B, on "Sources of national expenditures for R&D to performing sectors: 1991–98"

Funding Sector:	Total U.S.	Federal Government			
Performing Sector	Total U.S.	Total	Federal Govt.	Industry 2/	Industry FFRDCs 2/
Data Column	[1]	[37]	[2]	[4]	[6]
Calendar Year 5/	[Millions of current dollars]				
1991 7/	160,521	60,564	15,249	24,095	2,277
1992	164,933	60,694	15,853	22,369	2,353
1993	165,188	60,351	16,532	20,844	1,965

Appendix tables B-2 through B-4 are structured in exactly the same manner as appendix table B-1, but they refer to basic research, applied research, and development, respectively, rather than total R&D (the sum of those three components).

Plans for Additional Improvements

A separate methodological report to accompany *National Patterns of R&D Resources.* This and previous *National Patterns* reports contained broad descriptions of how data were compiled, how estimates were made, and how these methods have been revised over the years. As the amount of information in the report has grown, however, and as methods have become more complicated in many cases, it was determined that the provision of such information should not be subject to the space limitations that normally exist in the creation of the *National Patterns* report. Therefore, the Division of Science Resources staff is now producing a separate document, entitled *Methodology and Procedures Underlying the National Patterns Report*.

The new methodological report will differ from the kind of methodological information previously provided within earlier *National Patterns* reports in the following ways:

- The language and style of the report will be more technical, displaying, for example, the equations used in estimation, and the mathematical concepts underlying the use of those equations.

- The report will take advantage of the column-numbering system described above, by using column numbers, e.g., "[1]", as shorthand for the concept that it measures, thereby facilitating the use of equations to describe methods.

- An effort will be made to document all methods of calculation underlying the *National Patterns* report. Such documentation will be provided at a level of detail great enough for colleagues to reproduce the exact results provided in the *National Patterns* report from the same raw data, if they so choose. The column notations described above, and other descriptive techniques, will allow such documentation to be written concisely and be read easily.

- Much more information will be provided on the nuances of the *National Patterns* effort, which will provide data users with a better understanding of the statistical strengths and weaknesses of the different R&D statistics that are generated.

Definitions for Classification and Measurement

Classification of Sectors

The National Science Foundation (NSF) follows a four-sector division in reporting research and development (R&D) funds and personnel and maintaining time-series data on expenditures and employment. The sectors are: (1) industry, (2) the Federal Government, (3) universities and colleges, and (4) other nonprofit organizations. They are described in more detail below. Data also are collected for Federally Funded Research and Development Centers (FFRDCs), which are organizations exclusively or substantially financed by the Federal Government to meet a particular requirement or to provide major facilities for research and associated training purposes. Each center is administered either by an industrial firm, an individual university, a university consortium, or a nonprofit institution.

Federal Government. This sector consists of the agencies of the Federal Government.

Industry. This sector consists of both manufacturing and nonmanufacturing companies. Manufacturing companies are reported by major industry groupings. Nonmanufacturing companies include those in mining, construction, transportation, communications, and selected service industries such as R&D laboratories and computer and data processing services. Performance of FFRDCs administered by industrial firms generally is included in industry totals, although FFRDC breakouts are available and reported separately from R&D totals. Industry's funding of industry R&D includes all funds received from nonfederal sources (e.g., from state and local governments).

Universities and Colleges. This sector consists of all institutions of higher education, both public and private. Expenditures of FFRDCs administered by universities and colleges are reported separately from totals for this sector. University funding of university R&D includes: restricted or general funds that the institutions themselves have been free to allocate for research. Funds from the Federal Government, industry, state governments, or other nonprofit institutions, which are supplied in the form of grants or contracts for R&D at a university, are credited to the appropriate source. For example, research contracts from industry are treated as university performance funded by industry. Funds given to the institution by industry for general educational purposes and used by the school—at its discretion—for research are treated as university performance financed with the university's own funds.

Other Nonprofit Institutions. This sector consists of institutions that fall into two general groups: (1) organizations that are primarily granting in nature—i.e., private philanthropic foundations and voluntary health agencies; and (2) public and private organizations involved in performing R&D, including FFRDCs administered by nonprofit organizations.

Research and Development Categories

Research and Development. In this report R&D consists of basic and applied research in the sciences (including medical sciences) and in engineering and activities in development, all defined below.

The Federal, university, and nonprofit sectors include data for the broad fields of physical sciences, environmental sciences, mathematical sciences, computer sciences, life sciences, psychology, social sciences, engineering, and an all-inclusive "other sciences" category. Industry coverage is limited to: (1) the physical sciences, including related engineering and (2) the biological sciences, including medicine but excluding psychology. Industry R&D specifically excludes research in the social sciences.

Basic Research. Within the Federal, university, and nonprofit sectors, basic research is defined as research directed toward increases in knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific application toward processes or products in mind. For the industry sector, basic research projects are defined as "original investigations for the advancement of scientific knowledge . . . which do not have specific commercial objectives, although they may be in fields of present or potential interest to the reporting company."

Applied Research. Within the Federal, university, and nonprofit sectors, applied research is defined as research directed toward gaining ". . . knowledge or understanding necessary for determining the means by which a recognized and specific need may be met." The applied research definition for the industry sector is modified to include ". . . research projects which represent investigations directed to discovery of new scientific

knowledge and which have specific commercial objectives with respect to either products or processes."

Development. The NSF survey definition of development is ". . . the systematic use of the knowledge or understanding gained from research directed toward the production of useful materials, devices, systems or methods, including design and development of prototypes and processes." It excludes quality control, routine product testing, and production.

Defense-Space-Civilian Classification

This report contains data on: (1) the estimated percentage distribution of total U.S. R&D performance by national objective (table B-9) and (2) the reported distribution of Federal R&D authority by budget function (table B-10). The performer-based U.S. shares differ from the Federal budget authority shares for several reasons. The U.S. shares are based on expenditures reported by performers, which often spends Federal R&D funds in a year other than the one in which the Federal Government provided authorization, obligations, or outlays. In addition, the two series are based on different concepts. For example, whereas in the U.S. series all of the National Aeronautics and Space Administration's (NASA's) R&D funds are considered to be expenditures for space R&D, the budget authority data are distributed according to the functional categories that constitute the Federal budget. Thus, NASA's R&D budget authorizations are distributed between the space research and technology function and the transportation function.

"Defense R&D" consists of R&D spending by the Department of Defense (DoD) and defense-related atomic energy programs of the Department of Energy. All DoD activities are classified as defense, although some activities have secondary objectives (for example, space). "Space R&D" consists of R&D spending by NASA. All industry-funded R&D is classified as *civilian R&D*, including expenditures by aerospace and electronic industries.

Current Operating Costs

Funds used for R&D refer to current operating costs. These costs consist of both direct and indirect costs. They include not only salaries, but also fringe benefits, materials, supplies, and overhead. The R&D costs include depreciation, insofar as this information is available to respondents. Capital expenditures are excluded by definition in the surveys of the industry and academic sectors. Under the accounting practices of some Federal agencies, obligations for capital items may be included.

For universities and colleges, R&D data are for separately budgeted expenditures only. Consequently, these data exclude that portion of salaries for research time or other research expenses financed by funds not specifically earmarked for R&D from state and local governments and other non-federal sources, including endowments.

Intramural Federal Performance of R&D

Intramural R&D performance by Federal agencies refers to work carried on directly by agency personnel. Federal obligations reported under this category are for activities performed by the reporting agency itself or represent funds that the agency transfers to another Federal agency for performance of work, *as long as the ultimate performer is that agency or any other Federal agency*. If the ultimate performer is not a Federal agency, the survey questionnaire requests that the funds so transferred be reported by the transferring agency under the appropriate extramural performer category (universities and colleges, other nonprofit institutions, or industrial firms). Accurate identification of the ultimate performer is not always made.

Intramural activities cover not only the actual intramural R&D performance, but also the costs associated with the planning and administration of both intramural and extramural programs by Federal personnel. Intramural activities also include the costs of supplies and equipment, essentially of an "off-the-shelf" nature, that are procured for use in intramural R&D. For example, the purchase from an extramural source of an operational launch vehicle (i.e., one that has gone beyond the development or prototype stage) that is used for intramural performance of R&D is reported as a part of the cost of intramural R&D.

Controlling for Inflation and Foreign Currency

In the tables and figures of this report, the term "current dollars" refers to dollar amounts as they are measured and exchanged in the actual year, or years, in

question. In contrast, "constant dollars" refers to dollar amounts normalized for inflation. For example, if the same dollar amount is reported for two different years, and expressed as "current dollars," then fewer actual goods and services could be purchased with that amount in the most recent year than in the earlier year, because of inflation. If the same amount is expressed as "constant dollars," then it would be normalized for inflation in both years and, consequently, the same purchasing power would exist in each of the 2 years. Terms that are equal in meaning to "current" and "constant" dollars are, respectively, "nominal" and "real" dollars. These terms are also used to describe changes in dollar amounts over time. For instance, suppose a particular type of expenditure, when expressed in constant dollars, grew at a rate of 5 percent, per year, over a 10-year period. Such growth may be described as 5-percent growth "in real terms," or equivalently, "real growth" of 5 percent, meaning the constant-dollar amounts grew at a 5-percent rate, while the current dollar amounts grew at a greater rate due to inflation.

In keeping with U.S. Government and international standards, R&D trend data usually are deflated to 1992 constant dollars using the Gross Domestic Product (GDP) implicit price deflator. (See table B-5.) Since GDP deflators are calculated on an economy-wide rather than R&D-specific basis, their use more accurately reflects an "opportunity cost" criterion, rather than a measure of cost changes in doing research. That is, the GDP deflator, when applied to R&D expenditure or funding data, reflects the value of R&D in terms of the amount of other goods and services that could have been purchased with the same amount of money. The constant dollar figures reported here thus should be interpreted as real resources foregone in engaging in R&D rather than in other activities such as consumption or physical investment.

Broad-based deflators—such as the GDP deflator—could also be useful in approximating changes in the costs of conducting R&D activities.[1] However, these deflators are less appropriate for calculating real R&D costs at a disaggregated level, e.g., in estimating the costs over time of conducting the level of R&D within a particular science or engineering subfield. In addition, even when an opportunity cost criterion is used, the usefulness of the deflator is constrained by the length of the time span examined—the longer the time span, the less meaningful the deflator. That is, over long spans of time, such as 20 years, dramatic changes in the makeup of goods and services create ambiguities in the interpretation and measurement of quality change, which in turn, adversely affect the ultimate reliability of price deflators.[2]

As mentioned in the General Notes, all dollar amounts reported in the main text (as opposed to the tables or figures) are in current dollars. However, all growth rates reported are in "real terms," i.e., they were calculated based on the corresponding real values (in constant 1992 dollars) of the reported current dollars.

Comparisons in this report of U.S. and international R&D expenditure data are based on reported R&D investments converted to U.S. dollars using "purchasing power parity" (PPP) exchange rates. PPP exchange rates are designed to reflect differences in the purchasing power of currencies, based on the quantity of currency needed in order to purchase equivalent quantities of actual goods and services in the countries in question. That is, PPP exchange rates reflect real purchasing power, in the same sense that "real dollars," described above, control for inflation. The PPP exchange rates used are generally not equivalent to "market exchange rates," i.e., how much one currency would cost if one were to buy it (with another currency) from a financial institution. This is because market exchange rates are often influenced by factors other than real purchasing power, namely the relative supply of, and demand for, different currencies in international financial markets. A PPP exchange rate would not be equivalent to an ideal "R&D exchange rate," which does not exist at present, but would, in theory, account for international differences in R&D costs alone. Nevertheless, the PPP exchange rate is generally better at reflecting differences in R&D costs between countries than a market exchange rate.

Performer Reporting

There is no single survey of R&D activity in the United States. Rather, NSF sponsors a series of surveys to collect data on the financial and human resources devoted to R&D in the various sectors of the U.S. economy (defined above). Although these surveys are not designed

[1] See J.E. Jankowski, "Do We Need a Price Index for Industrial R&D?" *Research Policy* 22: 195-205.

[2] See M. Boskin, E. Dulberger, R. Gordon, Z. Griliches, and D. Jorgenson, "Consumer Prices, the Consumer Price Index, and the Cost of Living," *Journal of Economic Perspectives*, Vol. 12, No. 1, Winter 1998, 3–26; W. Nordhaus, "Quality Change in Price Indexes," *Journal of Economic Perspectives*, Vol. 12, No. 1, Winter 1998, 59–68; and S. Payson, *Quality Measurement in Economics: New Perspectives on the Evolution of Goods and Services* (Hants, England: Edward Elgar Publishing, Ltd., 1994).

specifically for this purpose, they provide the primary source material for estimating the national R&D totals. Respondents indicate the amounts they spend on R&D in their own sector and, generally, the sources of these funds. To the greatest extent possible, national totals are based on data as reported by performers because they are in the best position to: (1) indicate how much they spent in the actual conduct of R&D in a given year; (2) classify their work as basic, applied, etc.; and (3) identify the sector of the economy in which their financing originated. For those reasons, and because the consistent use of performer reporting reduces the possibility of double-counting and conforms to international standards (as outlined by the Organisation for Economic Co-operation and Development), R&D data are presented on a performer basis whenever possible.

Separate R&D performance totals are reported for: (1) the Federal Government, (2) industry, (3) industry-administered FFRDCs, (4) universities and colleges, (5) university-administered FFRDCs, (6) other nonprofit organizations, and (7) nonprofit-administered FFRDCs. R&D performed by state and local government agencies is not included in the national R&D totals. When state and local governments are listed by a survey respondent as the source of non-federal R&D funds, those amounts are included in the source totals of the sector reporting the R&D performance, except for university performance in which state funding is listed separately. For example, state-government support of industrial R&D is counted under industry's own support for industrial R&D.

Federal Government

Federal Performance Expenditures. Federal agency R&D obligations for intramural performance are treated as the equivalent of R&D expenditures in the *National Patterns* series. As detailed in the *Federal Funds for Research and Development* series *(Federal Funds),* such intramural activities cover costs associated with the planning and administration by Federal personnel of intramural and extramural R&D programs as well as actual intramural R&D performance. (See NSF/SRS, *Federal Funds for Research and Development: Fiscal Years 1996, 1997, and 1998,* Detailed Statistical Tables, NSF 99-332.) In general, the universe of Federal agencies with R&D programs has been surveyed annually since 1953 for their R&D performance, and since 1963 for the distribution of R&D by character of work. The most recent survey included R&D funding as reported by more than 300 reporting sites aggregated into 94 individual respondents from 31 Federal agencies or their subdivisions.

Federal Agencies as a Source of R&D Funding. NSF collects data on federally financed R&D from both Federal funding agencies and performers of the work (Federal labs, industry, universities, and other nonprofit organizations). As reported by Federal agencies, *National Patterns* uses data on Federal R&D budget authority and outlays, in addition to Federal obligations. The use of each series is clearly noted in the text.

Budget authority is the primary source of legal authorization to enter into financial obligations that will result in outlays. Budget authority most commonly is granted in the form of appropriations laws enacted by Congress with the approval of the President.[3]

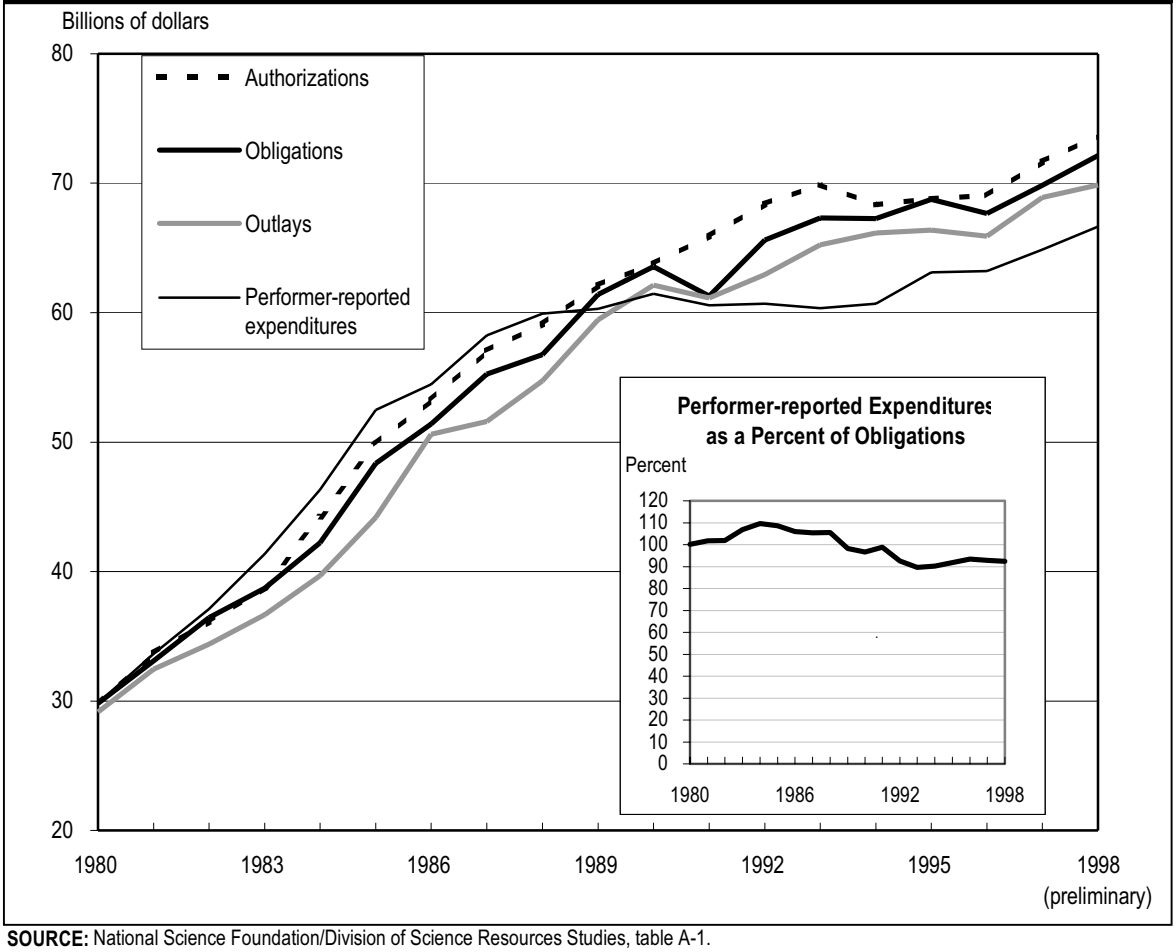
Obligations represent the amounts for orders placed, contracts awarded, services received, and similar transactions during a given period, regardless of when the funds were appropriated and when future payment of money is required.

Outlays represent the amounts for checks issued and cash payments made during a given period, regardless of when the funds were appropriated or obligated.

For the reasons above cited, national R&D expenditure totals are constructed primarily based on data reported by performers and include estimates of Federal R&D funding to these sectors. But before performer-reported survey data on Federal R&D expenditures are available from industry and academia, data collected from the Federal agency funders of R&D are used to project R&D performance. When survey data from the performers subsequently are tabulated, these statistics replace the projections that were based on the funders' expectations. Historically, the two survey systems tracked fairly closely. For example, in calendar-year 1980 performers reported using $29.9 billion in Federal R&D funding, and Federal agencies reported total R&D funding in fiscal year 1980 between $29.2 billion in outlays and $29.8 billion in obligations. In recent years, the two series have diverged considerably: For calender year 1998, performers report $66.6 billion in Federal R&D support, by preliminary estimates, compared with $72.1 billion reported by Federal agencies for fiscal year 1998 (table A-1 and figure A-1).

[3] See *Federal R&D Funding by Budget Function: Fiscal Years 1997–98 (Budget Function),* NSF 99-315.

Figure A-1. Alternative definitions of Federal R&D, all performers: 1980–98



SOURCE: National Science Foundation/Division of Science Resources Studies, table A-1.

The difference in the Federal R&D data totals appears to be concentrated in funding of industry (primarily aircraft and missile firms) by the Department of Defense (table A-2). Overall, industrial firms have reported significant declines in Federal R&D support since 1990 while Federal agencies reported level or slightly increased funding of industrial R&D. For fiscal year 1998, Federal agencies report $31.7 billion in total R&D obligations provided to industrial performers (excluding industry-administered FFRDCs) compared with an estimated $22.5 billion in Federal R&D funding reported by industrial performers. NSF is investigating causal factors for these divergent trends.

INDUSTRY

Sample Design Prior to 1992. In general, the industry sector has been surveyed annually since 1953 for its total R&D performance and since 1956 for the distribution by character of work. The U.S. Bureau of the Census conducts the survey for NSF. The target population of the survey is companies, whether U.S. or foreign-owned, that perform R&D in the United States. Prior to the 1992 survey, a new sample was drawn and canvassed only every 5 or 6 years (for example, in 1976, 1981, and 1987). In the intervening years, a subset of the last sample—called a panel and including all companies reporting more than $1 million in R&D—was surveyed. As a result, for the 1987 survey approximately 14,000 firms were selected for the sample. For the 1988 through 1991 studies, approximately 1,600 of these firms were resurveyed annually; the other firms did not receive another questionnaire, and their R&D data were estimated though not observed. Accordingly, data for the years in which a sample was not drawn did not include companies that were new entrants in the R&D field, and such data were generally biased in a downward direction. The Census Bureau, however, did estimate the annual changes in R&D data for companies that reported R&D in the sample year but were not included in the panel. As new samples were drawn, revisions to previous years' estimates were issued through a process called "wedging."

For example, a new sample was drawn for 1987, from which R&D data were collected for 1986 as well as 1987. Census used the data from the new sample to revise 1986 R&D performance estimates. The new 1986 data were also used by Census in combination with data from the last sample year, 1981, to revise estimates for the intervening years. NSF subsequently provided a second round of revisions to the 1982–85 R&D series. In both cases the revisions were done on an industry basis: an effort was made to apply the overall 1981–86 growth rates while preserving the relative year-to-year movements in each industry's R&D. This approach resulted in major revisions of the 1982–87 industry R&D time series previously published in *National Patterns*, especially of the nonfederally funded component of industry's R&D performance. The revised totals, as well as the industry data reported in *National Patterns: 1990* (NSF 90-316), were presented in table B-3 of *National Patterns of R&D Resources: 1996* (NSF 96-333). (Some of these data have since been revised, but the revisions were unrelated to the drawing of a new sample.)[4] Additional details on survey methods, coverage, concepts, definitions, and reliability of the estimates associated with the R&D expenditure data are contained in the 1990 edition (NSF 94-304) of the *Research and Development in Industry* series (*Industry R&D*).

Sample Design Revision in 1992. More recent surveys of industrial R&D performers have included revised R&D data based on relatively large industry samples. In contrast to data being based on probability samples selected approximately every 5 years, in 1992 NSF began to draw new samples annually, with the size of each sample increasing to approximately 24,000 firms. Industry classifications also were updated. The new sampling method now better reflects the widening population of R&D performers among firms in nonmanufacturing industries and small firms in all industries. As a result of these survey improvements, the revised 1991 industry R&D performance total ($117 billion) was 14 percent higher than was previously reported ($102.2 billion), and the national R&D total 10 percent higher. These revisions were first reported in *National Patterns: 1994* (NSF 95-304).

Of the $14.7 billion revision, $13.7 billion resulted from the new sample and $1.0 billion from normal data revisions for firms sampled in both surveys. Furthermore, $11.4 billion of the $13.7 billion increase stemming from the enlarged sample design was reported for nonmanufacturing industries, including $2.0 billion of R&D in industries not previously included in the sample frame. Complete technical details on industry's new survey methodology are contained in *Research and Development in Industry: 1992* (NSF 95-328).

As in previous sampling cycles, *National Patterns* includes revisions to the industry data for years intervening the 2 sample years (i.e., for 1988, 1989, and 1990). The industry and U.S. time series reported here include the wedged data reported for 1988–90 and the revised data for 1991–92. Table A-4 provides summary statistics for wedged data that appeared in *National Patterns of R&D Resources: 1994*, along with other data that were previously published.

For almost all of the aggregate statistics (for example, industry R&D by Federal and non-federal sources of funding), NSF believes that time series comparisons (for example, between 1981 and 1994 data) are still reasonable: Surveys undertaken in both years provided the best estimates of the Nation's industrial R&D performance total by sampling those industries then believed to be conducting R&D. However, changes in the survey series between some data elements for consecutive years may be problematic. Not only do the 1987 and 1992 surveys' sample size and frame differ considerably (see above), but $9.2 billion (in constant 1992 dollars) of R&D performed by firms reporting in both surveys was shifted from one industry in 1987 to another in 1992—especially from manufacturing industries in 1987 to nonmanufacturing industries in 1992. Such classification shifts can be attributed to (1) product mix changes of individual firms that occurred some time during 1987–92, (2) changes in the 1987 SIC that were effected in the 1992 survey, and (3) a change in the methodology used by NSF/Census for classifying companies to specific two- and three-digit SIC industries. Given that NSF has been committed since 1992 to drawing new samples annually, the question of wedging, and the reporting biases it creates, is unlikely to recur.

Use of "Nonmanufacturing" as a Single Industrial Category. The enormous growth in, and increasing economic importance of, "nonmanufacturing industries" is common knowledge. In this vein, the listing of a "nonmanufacturing" sector (which would include all

[4] Note that, although the Bureau of Census re-estimated 1982–86 R&D totals by funding source, it did not provide a character-of-work distribution for the revised data. After investigating several possible alternatives, NSF chose to allocate the revisions on the basis of average character-of-work distribution published in earlier annual *Industry R&D* reports. Allocations for the federally funded and nonfederally funded R&D revisions were applied separately.

services) in tables that compare it to specific manufacturing sectors like "primary metal products" in earlier *National Patterns* report was a somewhat archaic method of categorizing U.S. industries. Consequently, the current report provides several new categories all fitting under "nonmanufacturing," although no historical data exist for these categories prior to 1995.

Nevertheless, analysts of R&D patterns might wish to consider that "where R&D is located," in terms of the industrial R&D data presented in this report, is based on the classification of firms that perform the R&D, but may explain little about the forces underlying such R&D activities. In particular, many new forms of equipment and materials that result in technological innovation in services derive from R&D in manufacturing where such equipment and materials are first made. Health services is a case in point: continual innovation in medical services generally result from R&D in the manufacture of pharmaceuticals and new medical equipment. Because such R&D was carried out for the specific purpose of improving *services*, the attribution of such R&D to manufacturing rather than services is a matter of interpretation and precedence, not some absolute difference between the sectors in terms of their dependence on, or promotion of, scientific and engineering advances.[5]

Another issue is that services and manufacturing often differ in the nature of the R&D that they conduct. As a result, the relative quantity of R&D measured for services, in comparison to manufacturing, depends on how R&D is defined. For example, software development for particular computer entertainment packages, which would fall under services, would involve idea development that integrates computer science techniques with artistic creation. Whether such an activity would be classified as "R&D" would be a matter of interpretation and degree. In contrast, research on new hardware equipment would be much less subject to interpretation, and would tend to be automatically classified as R&D.

Character-of-Work Revisions. As first noted in the *National Patterns of R&D Resources: 1990*, the procedures used by the Census Bureau for imputing character-of-work splits for industry's R&D performance were changed for 1986 and later years; hence, these data are not directly comparable with data for 1985 and earlier years. A full description of the various imputation methodologies—and alternatives—is presented in the 1988 *Industry R&D* report (NSF 90-319). Briefly, for 1985 and earlier, for companies that did not report character-of-work splits, the Census Bureau imputed the splits based on either (1) the company's percentage distribution reported in its most recent year of available data or (2) in the absence of any prior year breakdown for the company, the average character-of-work split for the industry to which the company was assigned. For years after 1985, the Census Bureau does not impute a company's character-of-work distribution unless the company has reported a breakout within 2 years of the year being imputed. When distributions are not imputed, the Census Bureau assigns the company's R&D to an "undistributed residual" category.

To provide character-of-work estimates for the entire population of firms performing R&D in the United States, each industry's (as contrasted with each individual company's) "undistributed residual" is allocated to basic research, applied research, and development categories using the average character-of-work splits reported for that industry. This approach resulted in relatively higher performance shares for basic and applied research than had been previously estimated and relatively lower estimates for development's share of industry's total R&D performance.

Universities and Colleges

The academic sector, including all university-administered FFRDCs, has been surveyed for R&D performance annually, by fiscal year, since 1972. It was surveyed less frequently before 1972. For 1994–97, data were collected from a sample of the 681 institutions of higher education in the United States and outlying areas that (1) granted a graduate degree in science or engineering and/or (2) performed activities for which at least $50,000 had been funded from separately budgeted R&D expenditures. Roughly 500 institutions were sampled annually, comprising all doctorate-granting

[5] For more detailed discussion on the interrelationship between R&D in manufacturing and advances in services, see, for example, B. Guile and J. Quinn, eds. *Technology in Services: Policies for Growth, Trade, and Employment* (Washington, DC: National Academy Press, 1988). For more general discussion of the causal relationship between R&D and industrial growth, see, for example, Adams, J.D. (1990) "Fundamental Stocks of Knowledge and Productivity Growth." *Journal of Political Economy.* Vol. 98, No. 4: 673–702; Bernstein, J.I., and M.I. Nadiri. 1988. "Interindustry R&D Spillovers, Rates of Return, and Production in High-Tech Industries." *American Economic Review, Papers and Proceedings* Vol. 78: 429–34; and Jaffe, A. 1986. "Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits, and Market Value." *American Economic Review* Vol. 76: 984–1001.

institutions, all historically black colleges and universities with any R&D expenditures, and a random sample of all other institutions. For fiscal year 1993, data were collected from the full population of 681 institutions that met the criteria listed above.

Character-of-Work Revisions. With the exception of 1978, data on the basic research performance of universities and colleges and of university-administered FFRDCs have been collected annually since 1972. Since 1979, however, only the combined total for applied research and development performance has been collected. Furthermore, data on the character of work from individual non-federal sources of funds (i.e., industry, institutional funds, state and local governments, and other sources) are not surveyed. For the years 1978 to the present, the distribution of applied research and development from Federal sources is based largely on data from *Federal Funds.* The method of estimation for these levels is provided in the forthcoming methodology report.

Revised estimates for Federal funding of applied research and development to universities and colleges and to university-administered FFRDCs were first included in the *National Patterns of R&D Resources: 1992.* University performers report the amount of R&D and basic research that they undertake using Federal funds. The residual is their combined applied research and development performance. The distribution between applied research and development is approximated from the percentage shares of Federal obligation data to the academic sector as reported by Federal agencies in *Federal Funds.* Although the estimating procedures used previously had been loosely based on the data provided by the Federal funding agencies, the approach adopted here formally links the performer- and source-reported survey data. Applied research and development expenditures for universities and colleges were revised for the period 1978–present; for university-administered FFRDCs, revisions were made back to 1975. The general result is that the applied research share is slightly lower and the development share somewhat higher than previously reported.

Subcontracting. Only for the academic sector does R&D performance include research funds subcontracted to outside organizations. (For performance reported by respondents in the other surveyed sectors, R&D subcontracted to other organizations is excluded.) Details on survey methods, coverage, concepts, definitions, and reliability of the estimates associated with the R&D expenditure data are reported in the fiscal year 1996 report, *Academic Research and Development Expenditures (Academic R&D),* NSF 98-304. There is preliminary evidence from NSF surveys that approximately 3 percent of total academic R&D funds are passed through the university to other recipients.

Other Nonprofit Institutions

It has not been possible to maintain the same survey frequency for other nonprofit institutions; the last complete survey was conducted in 1973. Since then, small and informal surveys of this sector have been undertaken periodically.

For the years 1984 to the present, estimates for federally funded total R&D and character-of-work performance by nonprofit institutions—including associated FFRDCs—are derived from Federal obligation data reported in *Federal Funds*. Industry as a source of R&D funds to this sector is approximated using the average of the annual percentage change in (1) industry's funding of industry-performed R&D (from *Industry R&D)* and (2) industry funding of university-performed R&D (from *Academic R&D*). Nonprofit funding as a source of R&D funds to this sector is approximated based on the annual percentage change in nonprofit funding of university-performed R&D (from *Academic R&D*). The character-of-work splits from the non-federal funding sources that were surveyed in 1983 are carried forward to the present.

DATA ANALYSIS

PRELIMINARY DATA AND PROJECTION PROCEDURES FOR 1997 AND 1998

To the greatest extent possible, this report incorporates data for 1997 and 1998 R&D programs that are presented in the administration's 1999 budget proposal. For example, the 1999 budget contains data on total R&D outlays and budget authority by agency and by character of work. However, the budget does *not* contain reliable estimates on the amount of Federal R&D funds received by each of the R&D-performing economic sectors; it only shows the federally funded totals and funds received by universities and colleges. The detailed sector-specific information is obtained from an NSF survey of Federal agencies' R&D obligations, which is collected after the President's proposed budget has been published. For this reason, some of the 1997 and 1998 Federal R&D data reported here are based on the administration's 1998 budget proposal.

Preliminary R&D performance totals in *National Patterns* are calculated for each sector, by character of work, and by source of funds from surveys and time-series extrapolation techniques, as follows.

Federal Government. Projections for 1997 and 1998 are *based on* changes in intramural R&D obligations reported in *Federal Funds*. The amounts reported for 1997 are preliminary and reflect congressional appropriations, apportionment, and reprogramming decisions as of the third quarter of FY 1998. Data for 1998 are projections that reflect the changes in intramural R&D represented in administration 1999 budget proposals.

Industry. Preliminary data for company-funded 1997 and 1998 performance are based on industry responses to the 1997 *Industry R&D Survey*, as of June 1998. This sample of preliminary responses accounted for approximately 50 percent of the R&D performed by industrial firms in 1996.

Universities and Colleges. Preliminary data for 1997 are based on university responses to the FY 1997 *Academic R&D Survey*, as of June 1998. These respondents accounted for approximately 90 percent of the R&D performed by universities and colleges in FY 1996.

Other Nonprofit Institutions. Preliminary tabulations for 1997 and 1998 are based on (1) Federal obligations reported in *Federal Funds* (NSF 98-332) and (2) time series modeled extrapolations of recent trends in R&D performance and funding within the industry and university sectors. (The method of estimation for these levels is provided in the forthcoming methodology report.)

USE OF TIME-SERIES DATA

Data presented in trend tables are assembled from the most recently completed survey cycles. Data for prior years are reviewed for consistency with current year's responses and—when necessary—revised in consultation with survey respondents. In addition, changes in sample design or imputation methodologies can result in revisions to previously published data. For trend comparisons, the historical data contained in this report should be used rather than the data published in previous *National Patterns* volumes.

GEOGRAPHIC DISTRIBUTION

This report contains information on the state distribution of R&D performance for 1995 (tables B-7 and B-8). These data cover R&D performance by industry, academia, Federal agencies, and the federally funded R&D activities of nonprofit institutions. These state-distributed data are meant to be indicative of general distribution patterns; they are not necessarily precise.

State-distributed data for the industry sector are collected for odd-numbered years. The latest available detailed data are for 1995 and are from *Research and Development in Industry: 1995–96* (NSF 99-312). The data include R&D performance by industry-administered FFRDCs.

State-distributed data for Federal laboratories are intramural R&D obligations in FY 1995. These data are available from the 10 major R&D-supporting agencies *(Federal Funds)*.

State-distributed data for the academic sector are collected only for doctorate-granting institutions and

university-administered FFRDCs *(Academic R&D)*. R&D performance by an FFRDC is assigned to the state in which the FFRDC is located, which is not necessarily the state in which the administering institution is located.

State-distributed data for other nonprofit institutions are Federal R&D obligations to this sector in FY 1995 as reported by the 10 major R&D-supporting government agencies *(Federal Funds)*. These agencies provided approximately 98 percent of total Federal R&D obligations in 1995. Data on R&D performance by this sector using non-federal sources of funds are not collected.

HUMAN RESOURCES

The 1994 *National Patterns* was the first to include revised data on scientists and engineers (S&Es) engaged in R&D activities. This national series consists of separate survey estimates of R&D S&Es employed in industry and in the Federal Government and doctorate-holding R&D S&Es employed in educational institutions and in nonprofit organizations. The industry series are for S&Es employed on a full-time-equivalent basis; totals for the other sectors reflect the primary work activity of S&Es.

A variety of surveys and estimation techniques are used to gather information on the numbers and characteristics of persons engaged in science and engineering activities in all sectors of the economy. In general, two types of surveys report worker inputs for R&D: surveys directed at individuals and surveys directed at employers.

SURVEYS OF INDIVIDUALS

These surveys (in this report, of scientists and engineers holding doctorate degrees) result in data on the primary work activities and demographic and economic characteristics of the respondents. In the survey of doctoral scientists and engineers, respondents are asked to report their primary work activity—i.e., the activity on which they spend the largest proportion of their time, but that is not necessarily a full-time activity. This survey is conducted only in odd-numbered years. The latest tabulated data are available for 1995 and are summarized in appendix table B-28. Details on survey methods, coverage, concepts, definitions, and reliability of the estimates associated with these S&E data are in *Characteristics of Doctoral Scientists and Engineers in the United States: 1995* (NSF 97-319).

SURVEYS OF EMPLOYERS

These surveys generally are focused on the amount of time—in terms of person-years—devoted to the performance and management of R&D. In this report, data on the number of S&Es—not just those holding doctoral degrees—employed by industry on an full-time-equivalent (FTE) basis in R&D are summarized in appendix table B-27. For example, if each of two scientists/engineers spends 50 percent of the workday on R&D, the equivalent is one FTE R&D job.

Previously, the *National Patterns* provided national estimates of FTE R&D scientists and engineers. At one point, SRS had survey data for FTE estimates in all sectors of the economy. Currently, SRS collects such data only for the industrial sector. The last FTE R&D manpower survey of the academic sector was for 1985, and the last manpower survey of the nonprofit sector was for 1973, although a small telephone survey was conducted for 1983. The loss of such survey data had necessitated increased reliance on analytically derived figures (including the use of regression equations) that were based largely on estimating assumptions that could not be empirically tested for their continued validity. Consequently, those preliminary series are replaced here with survey counts of the number of doctorate-holding S&Es who self-report their primary work activity as R&D or R&D management. How well these head counts might approximate an FTE estimate is unknown. On the one hand, these head counts may provide an overestimate of FTE activity since many of the surveyed S&Es are not engaged in R&D full-time even though it is their primary work activity. On the other hand, this approach may underestimate FTE R&D personnel since it does not account for S&Es engaged in R&D who do not hold a doctorate degree. Sources for the revised estimates and comparison with the 1985 and 1989 figures published in *National Patterns: 1992*, are described and summarized in table A-7. For the total United States, the revised figures for 1989 (924,200) are 3 percent lower than previously reported (949,300).

Industry. Industry is the only sector for which FTE R&D S&E survey estimates are available. Firms report (*Industry R&D)* FTE employment levels for January of each year, and a simple 2-year moving average is used for the national R&D S&E series. For example, the total reported for 1989 (733,000) is the average of the level reported by firms for January 1989 and January 1990. Except for minor data revisions resulting from the inclusion of wedged statistics, the industry totals reported here do not differ from those reported previously. As detailed above for the industry expenditure data, improvements in the sample design for 1992 and later years resulted in data that now better reflect R&D performance among firms in the nonmanufacturing industries and small firms in all industries.

Federal Government. For the Federal sector, survey data on civilian scientists and engineers are collected

annually (*Federal Scientists and Engineers*: *1989–93*, NSF 95-336). The estimates are compiled from the U.S. Office of Personnel Management's (OPM's) Central Personnel Data File on all white collar civilian jobs and are reported in terms of primary work activities. Scientists or engineers are included in the *National Patterns* totals if their primary work activity is research or development. These head counts exclude (1) military personnel (but include civilian S&Es employed in defense agencies) and (2) Federal employees classified in a management occupational code, even if they manage an R&D program. The earliest year for which these OPM statistics have been compiled is 1985. Data for 1985–89 published in the previous *National Patterns* included estimates for R&D managers, which are no longer included in the Federal totals. For years prior to 1985, the figures were based on NSF surveys since discontinued.

Universities and Colleges. For the academic sector two series are reported: doctoral scientists and engineers and graduate students doing research. The head counts for research students are from the *Survey of Graduate Students and Postdoctorates in Science and Engineering* and are for full-time science and engineering graduate students in all institutions whose major financial support is research assistantships. In this revised series FTE estimates are derived assuming a 50-percent workload (or working half-time on R&D), whereas previously a 47-percent workload assumption was used.

Academic institutions were previously surveyed for estimates of FTE R&D S&Es; however, 1985 is the most recent year for which this survey was conducted. Since then the academic estimates published in *National Patterns* were usually derived from a regression of the 1975–85 academic FTE survey data on (1) academic R&D expenditures and (2) the number of academic doctoral S&Es who reported R&D as their primary work activity. The revised series directly utilizes reported employment levels from the *Survey of Doctorate Recipients (SDR)*. The academic R&D employment totals are of doctoral scientists and engineers employed in all educational institutions who self-report their primary work activity as "research," "development or design," or the "management or administration of R&D." No adjustments are made to derive full-time equivalents. For 1989, the revised primary work activity total, (83,500), is approximately 11 percent less than the FTE figure, (93,700), last published in *National Patterns.* Since the doctoral data are collected only biennially, the revised national FTE series also are reported biennially.

NSF introduced a number of improvements into the 1991 SDR (for example, changes in the age-based cohorts collected and in the definition of doctoral scientists and engineers) that may affect comparability with SDR data published for prior survey years. The academic S&E total for those reporting R&D as their primary work activity for 1989 is 83,500 and the total for 1991 is 74,600. Whether changes in the survey design or in actual employment patterns caused the academic R&D S&E decline is unknown. Analysts should consult the report, *Characteristics of Doctoral Scientists and Engineers in the United States: 1991* (NSF 94-307) for more information on these methodological changes.

Other Nonprofit Institutions. The last survey of the nonprofit sector was for 1973. Since then the nonprofit estimates published in *National Patterns* generally were based on survey data from the early seventies and trends in the ratio of national R&D expenditures to FTE R&D S&Es. In the revised series, nonprofit R&D employment levels are taken from the *Survey of Doctorate Recipients*. The figures are for doctoral scientists and engineers employed in nonprofit organizations who self-report their primary work activity as "research," "development or design," or the "management or administration of R&D." No adjustments are made to derive full-time equivalents. For 1989, the revised primary work activity total (9,200) is approximately 75 percent less than the FTE figure (34,500) last published in *National Patterns*. The effect on the Nation's total FTE estimate is approximately a 2.7-percent downward revision.

List of Supporting Data Sources on R&D Expenditures

National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1996, 1997, and 1998*, NSF 98-332 (Arlington, VA, 1998). Detailed statistical tables cover R&D (and R&D plant) funding levels for FYs 1996–98 as reported by all Federal agencies with R&D programs. Includes data by agency, performer, character of work, geographic distribution, and field of science and engineering.

National Science Foundation, *Federal R&D Funding by Budget Function: Fiscal Years 1997–99*, NSF 99-315 (Arlington, VA, 1999). Provides information on Federal R&D budget authority by Federal budget function as proposed in the administration's 1999 budget.

Office of Management and Budget, *The Budget of the United States Government, Fiscal Year 1999* (Washington, DC: GPO, 1998). Provides quantitative and qualitative information on R&D funding as proposed in the administration's 1999 budget.

National Science Foundation, *Research and Development in Industry: 1995–96*, NSF 99-312 (Arlington, VA, 1999). Detailed statistical tables cover industrial R&D performance as reported in a sample survey of companies. Data include distribution by source of funds, industry classification, character of work, product field, geographic location, company size, and other tabulations.

National Science Foundation, *Academic Research and Development Expenditures: Fiscal Year 1996*, NSF 98-304 (Arlington, VA, 1998). Detailed statistical tables cover academic R&D performance as reported in a survey of U.S. universities and university-administered FFRDCs. Data include distribution by source of funds, performing institution, character of work, field of science, and geographic location.

TABLES CORRESPONDING TO TECHNICAL NOTES

Table A-1. Difference in agency-reported and performer-reported Federal R&D, all performers: 1980–99

Year	Reported by Federal agencies (by fiscal year)			Performer-reported expenditures (calendar year)
	Authorizations	Obligations	Outlays	
	[Millions of dollars]			
1980	29,739	29,830	29,154	29,857
1981	33,735	33,104	32,459	33,666
1982	36,115	36,433	34,391	37,113
1983	38,768	38,712	36,659	41,362
1984	44,214	42,225	39,691	46,319
1985	49,887	48,360	44,171	52,493
1986	53,249	51,412	50,609	54,475
1987	57,069	55,254	51,612	58,254
1988	59,106	56,769	54,739	59,930
1989	62,115	61,406	59,450	60,301
1990	63,781	63,559	62,135	61,457
1991	65,898	61,295	61,130	60,564
1992	68,398	65,593	62,934	60,694
1993	69,884	67,314	65,241	60,351
1994	68,331	67,257	66,151	60,700
1995	68,791	68,736	66,371	63,102
1996	69,049	67,663	65,910	63,215
1997 (preliminary)	71,653	69,830	68,897	64,865
1998 (preliminary)	73,639	72,114	69,849	66,636
1999 (preliminary)	75,229	73,333	71,112	NA

SOURCES: National Science Foundation/Division of Science Resources Studies. Federal Funds Survey, *Detailed Historical Tables, Fiscal Years 1951–98* ; *Federal Funds for Research and Development: Fiscal Years 1997, 1998, and 1999;* and Table B-6.

Table A-2. Difference in agency-reported and performer-reported Federal R&D: industrial performers by agency source, 1980–96

Year	Industry Survey (calendar year) 1/			Federal Survey—obligations (fiscal year) 1/			Difference in Report Totals		
	Total	Department of Defense	Other agencies	Total	Department of Defense	Other agencies	Total	Department of Defense	Other agencies
	[Millions of dollars]								
1980	14,029			14,377			(348)		
1981	16,382	10,540	5,842	16,282	10,931	5,351	100	(391)	491
1982	18,545			18,699			(154)		
1983	20,680	14,571	6,109	18,521	14,671	3,850	2,159	(100)	2,259
1984	23,396			20,219			3,177		
1985	27,196	20,948	6,248	23,496	19,069	4,427	3,700	1,879	1,821
1986	27,891			25,898			1,993		
1987	30,752	22,252	8,500	28,628	24,258	4,370	2,124	(2,006)	4,130
1988	30,343			28,631			1,712		
1989	28,554	NA	NA	30,604	25,043	5,561	(2,050)	NA	NA
1990	28,125			31,697			(3,572)		
1991	26,372	NA	NA	28,589	21,350	7,239	(2,217)	NA	NA
1992	24,722			31,862			(7,140)		
1993	22,809	15,044	7,765	31,670	23,856	7,814	(8,861)	(8,812)	(49)
1994	22,463			31,748			(9,285)		
1995	23,451	13,876	9,575	31,674	22,645	9,029	(8,223)	(8,769)	546
1996	23,653			31,498			(7,845)		

1/ Includes industry-admininstered federally funded research and development centers (FFRDCs).

KEY: NA = not available

NOTES: Data from the Industry Survey are R&D expenditures as reported by performing firms. Data from the Federal Survey are R&D obligations to industry as reported by Federal agencies. The last three columns report the difference between the two data series.

SOURCES: National Science Foundation/Division of Science Resources Studies. Federal Funds Survey, *Detailed Historical Tables, Fiscal Years 1951–98* ; *Federal Funds for Research and Development: Fiscal Years 1997, 1998, and 1999;* and *Research and Development in Industry: 1995–96.*

Table A-3. Revisions in industry R&D performance totals: 1982–87

Year	Total R&D			Non-federal funds			Federal funds		
	1989 National Patterns	Revision	1990 National Patterns	1989 National Patterns	Revision	1990 National Patterns	1989 National Patterns	Revision	1990 National Patterns
	[Millions of dollars]								
1982	57,995	655	58,650	39,512	593	40,105	18,483	62	18,545
1983	63,403	1,865	65,268	42,861	1,727	44,588	20,542	138	20,680
1984	71,470	3,330	74,800	48,308	3,096	51,404	23,162	234	23,396
1985	78,269	5,970	84,239	51,439	5,604	57,043	26,830	366	27,196
1986	80,631	7,548	88,179	52,848	7,084	59,932	27,783	464	28,247
1987	85,500	8,617	94,117	55,500	7,306	62,806	30,000	1,311	31,311

NOTE: These methodological revisions were first reported in *National Patterns of R&D Resources: 1990.* These data may have been subsequently revised since the methodological revisions were first introduced. Any such subsequent revisions are not reflected in this table.

SOURCE: National Science Foundation/Division of Science Resources Studies, *National Patterns of R&D Resources: 1990.*

Table A-4. Revisions in industry R&D performance, and their impact on other variables: 1987–91

Year	Total industry R&D		Non-federal funds to industry		Federal funds to industry		National R&D funds		R&D/GDP		Federal funds as percent of total		Defense R&D as percent of total	
	Previous estimates	1994 National Patterns	Previous estimates	1994 National Patterns	Previous estimates	1994 National Patterns	Previous estimates	1994 National Patterns	Previous estimates	1994 National Patterns	Previous estimates	1994 National Patterns	Previous estimates	1994 National Patterns
	[Millions of dollars]													
1987	92,155	92,155	61,403	61,403	30,752	30,752	125,376	125,376	2.8	2.8	46.2	46.2	31.3	31.3
1988	97,889	97,015	65,772	66,672	32,117	30,343	133,764	132,890	2.73	2.71	45.8	44.8	30.2	29.5
1989	101,854	102,055	70,562	73,501	31,292	28,554	140,824	141,025	2.68	2.68	44.5	42.5	28.4	27.1
1990	104,606	109,727	73,980	81,602	30,626	28,125	146,424	151,545	2.64	2.73	43.7	40.6	27.0	25.1
1991	102,246	116,952	25,308	90,580	25,308	26,372	145,383	160,096	2.54	2.80	40.7	37.6	24.3	22.3

NOTE: These methodological revisions were first reported in *National Patterns of R&D Resources: 1994.* These data may have been subsequently revised since the methodological revisions were first introduced. Any such subsequent revisions are not reflected in this table.

SOURCE: National Science Foundation/Division of Science Resources Studies, *National Patterns of R&D Resources: 1994.*

Table A-5. Distribution of industry R&D performance, by character of work: 1985–96

Year	Non-federal funds					Federal funds				
	Census imputation					Census imputation				
	Total R&D	Basic research	Applied research	Development	Undistributed residual	Total R&D	Basic research	Applied research	Development	Undistributed residual
	[Millions of dollars]									
1985	57,043	2,140	11,640	37,659	5,604	27,196	482	5,275	21,073	366
1986	59,932	2,162	9,914	29,081	18,775	27,891	370	3,444	17,074	7,003
1987	61,403	2,332	10,558	30,819	17,694	30,752	534	3,510	18,770	7,938
1988	66,672	2,315	11,507	33,061	19,789	30,343	731	3,255	18,829	7,528
1989	73,501	2,741	13,328	37,599	19,833	28,554	1,050	3,567	16,224	7,713
1990	81,602	3,519	14,867	38,610	24,606	28,125	981	3,684	17,495	5,965
1991	90,580	5,270	17,511	51,568	16,231	26,372	1,220	4,808	14,749	5,595
1992	94,388	5,076	18,223	58,907	12,182	24,722	910	4,325	16,780	2,707
1993	94,591	5,345	17,345	60,991	10,910	22,809	952	4,698	16,561	597
1994	97,131	5,453	16,894	63,719	11,065	22,463	921	4,040	16,217	1,285
1995	108,652	4,581	19,744	68,938	15,388	23,451	511	2,725	14,679	5,536
1996	121,015	5,897	21,373	77,434	16,311	23,653	1,114	3,013	14,420	5,106
	Reported in 1998 National Patterns					Reported in 1998 National Patterns				
1985	57,043	2,373	12,908	41,762	0	27,196	489	5,347	21,360	0
1986	59,932	3,496	15,082	41,354	0	27,891	551	4,678	22,662	0
1987	61,403	3,583	15,153	42,667	0	30,752	740	4,660	25,352	0
1988	66,672	3,507	16,531	46,634	0	30,343	993	4,217	25,133	0
1989	73,501	3,832	17,993	51,676	0	28,554	1,384	4,698	22,472	0
1990	81,602	3,760	18,432	59,410	0	28,125	1,368	6,353	20,404	0
1991	90,580	6,125	21,425	63,030	0	26,372	1,712	6,021	18,639	0
1992	94,388	5,816	21,184	67,388	0	24,722	1,186	4,983	18,554	0
1993	94,591	5,961	19,956	68,674	0	22,809	958	4,730	17,122	0
1994	97,131	6,078	19,372	71,681	0	22,463	939	4,119	17,405	0
1995	108,652	5,379	23,755	79,518	0	23,451	720	3,699	19,033	0
1996	121,015	6,848	25,370	88,797	0	23,653	1,358	3,871	18,424	0

NOTES: Because of rounding, detail may not sum to totals. These methodological factors were first reported for the years 1985–87 in *National Patterns of R&D Resources: 1990.* Industrial performance here includes industry-administered federally funded research and development centers (FFRDCs).

SOURCE: National Science Foundation/Division of Science Resources Studies.

Table A-6. Revisions in university & college performance by Federal source of funds: 1974–90

Year	Universities and colleges				University-administered FFRDCs			
	1990 National Patterns		1992 National Patterns		1990 National Patterns		1992 National Patterns	
	Applied research	Development	Applied research	Development	Applied research	Development	Applied research	Development
	[Millions of dollars]							
1974	438	71	438	71	178	297	178	297
1975	516	78	516	78	213	335	203	345
1976	584	87	584	87	264	371	235	400
1977	607	112	607	112	371	413	290	494
1978	673	122	644	194	431	419	319	531
1979	873	150	709	314	468	452	342	578
1980	1,043	200	880	361	503	619	424	698
1981	1,087	225	943	364	529	696	424	801
1982	1,142	225	957	406	606	556	430	732
1983	1,217	225	1,052	387	726	539	456	809
1984	1,401	200	1,187	410	804	671	541	934
1985	1,515	200	1,261	458	835	939	591	1,183
1986	1,611	225	1,329	512	774	1,262	565	1,471
1987	1,706	250	1,452	512	693	1,501	538	1,656
1988	2,229	275	1,857	694	697	1,612	534	1,775
1989	2,300	300	2,118	724	720	1,680	605	1,795
1990	2,325	325	2,219	857	740	1,760	630	1,799

KEY: FFRDCs = federally funded research and development centers

NOTE: These methodological revisions were first reported in *National Patterns of R&D Resources: 1992.* These data may have been subsequently revised since the methodological revisions were first introduced. Any such subsequent revisions are not reflected in this table.

SOURCE: National Science Foundation/Division of Science Resources Studies, *National Patterns of R&D Resources: 1992.*

Table A-7. Revisions in number of R&D scientists and engineers: 1985 and 1989

Sector and primary work activity	1985		1989	
	Previous data	Revised data	Previous data	Revised data
	[Thousands]			
Total United States R&D scientists and engineers	841.6	801.9	949.3	924.2
Industry: Number of full-time equivalent R&D S&Es	646.8	646.8	726.0	733.1
Federal Government: Number of S&Es, Total	55.0	52.1	60.0	58.8
Research	22.3	22.3	22.9	24.6
Development	29.7	29.7	33.2	34.2
R&D management	2.9	--	3.9	--
Educational institutions: Full-time equivalent R&D S&Es, total	81.1	--	93.7	--
Doctoral S&Es, total	--	64.7	--	83.5
Basic research	--	43.6	--	52.7
Applied research	--	15.7	--	26.0
Development/design	--	1.4	--	0.9
Management/administration of R&D	--	4.0	--	3.9
FTE S&E graduate students with research assistantships	27.2	30.5	35.1	39.5
Nonprofit organizations: Full-time equivalent R&D S&Es, total	31.5	--	34.5	--
Doctoral S&Es, total	--	7.8	--	9.2
Basic research	--	3.4	--	3.8
Applied research	--	2.2	--	3.2
Development/design	--	0.5	--	0.5
Management/administration of R&D	--	1.7	--	1.7
R&D S&Es per 10,000 labor force	71.8	68.4	75.6	73.0

KEY: FTE = full-time equivalent

NOTES: These methodological revisions were first reported in *National Patterns of R&D Resources: 1994.* These data may have been subsequently revised since the methodological revisions were first introduced. Any such subsequent revisions are not reflected in this table.

SOURCES: National Science Foundation/Division of Science Resources Studies, Survey of Industrial Research and Development; Survey of Doctorate Recipients; Survey of Graduate Students and Postdoctorates in Science and Engineering; U.S. Office of Personnel Management; and Bureau of Labor Statistics, Employment and Earnings (annual)